



Figure 9.2.2.1-2. Deconstruction of the PA by construction activities, including preconstruction studies (*i.e.*, geotechnical explorations).

Accidental Spills

Land-side proposed construction activities could result in the introduction of chemical contaminants to the waterway and adjacent shorelines. Hazardous materials from construction equipment, barges and towing vessels, and other machinery (heavy equipment) could leach or wash into the water or the soil along the shoreline. Vehicles may leak hazardous substances such as motor oil and antifreeze. A variety of substances could be introduced during accidental spills of materials. Such spills can result from leaks in vehicles, small containers falling off vehicles, or from accidents resulting in loads being spilled.

Accidental spills of contaminants, including oil, fuel, hydraulic fluids, concrete, paint, and other construction-related materials could result in localized water quality degradation and potential adverse effects on delta smelt. Potential effects of contaminants on delta smelt include physical injury and mortality (*e.g.*, damage to gill tissue causing asphyxiation) or delayed effects on growth and survival (*e.g.*, increased stress or reduced feeding), depending on the type of contaminant, extent of the spill, and exposure concentrations. The risk of such effects is highest during in-water construction activities, including cofferdam installation, levee grading and armoring, and barge traffic, because of the proximity of construction equipment to the river. However, implementation of CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*, AMM5, *Spill Prevention, Containment, and Countermeasure Plan*, and AMM14, *Hazardous Materials Management*, is expected to reduce the potential for contaminant spills and guide rapid and effective response in the case of inadvertent spills of hazardous materials. With implementation of these and other required construction BMPs (*e.g.*, AMM3, *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to the river from in-water or upland sources will be minimized. The nature, quantity, and extent of accidental spills associated with implementation of the PA are unknown until the time of the event occurs. In the event of an accidental spill, refer to 9.2.4 *Reinitiation Triggers* for further guidance.

9.2.2.1.1 Overwater Geotechnical Explorations

Effects to Individuals and the Population

Individual-level

Due to the duration of the geotechnical explorations (to occur at one location up to 60 days) and quantity of in-water borings (approximately 100), individual delta smelt are likely to be adversely affected by in-water work construction activities. To minimize these effects to the delta smelt, work windows will be implemented. The in-water work window is established to allow in-water work when the delta smelt are least likely to occupy the areas. The timing of the in-water construction activities (August 1 – October 31) will avoid the adult migration, spawning, incubation (*i.e.*, eggs/embryos), and larval transport phases. Overwater geotechnical explorations are scheduled to occur (August 1–October 31) when juvenile delta smelt will be rearing near the LSZ during the summer and fall months (approximately July – December). However, given the delta smelt's seasonal to transient use of the locations where the

geotechnical explorations will occur, it is expected that few rearing juveniles will be in the identified areas, resulting in an overall low number of individuals injured or killed.

Adverse effects to delta smelt will be difficult to detect due to their small size, low numbers, and rarity. However, effects are expected to be minimal given the low occupancy and low probability of effects to occur. For delta smelt present during the geotechnical explorations, adverse effects are likely to occur to individuals from disturbance from heavy equipment or materials, increased turbidity and suspended sediment, exposure to contaminants, disturbance of contaminated sediments, and disturbance or alteration to rearing and spawning habitat.

Increased Turbidity and Suspended Sediment

Delta smelt are adapted to turbid waters, where they presumably benefit from increased feeding efficiency and avoidance of sight-feeding predators. Laboratory experiments suggest that if turbidity gets higher than 250 NTU, then there is the potential for a strong decline in feeding (Hasenbein *et al.* 2013). However, the geotechnical explorations are not expected to create turbidity that reaches this threshold to adversely affect individuals from increases in turbidity.

Exposure to Contaminants and Disturbance of Contaminated Sediment

Suspension of sediments and contaminants will alter the localized conditions for rearing juveniles exposed to in-water work activities. Delta smelt using these areas could be exposed to contaminants that are present at the site. Exposure pathways could include respiration, dermal contact, direct ingestion, or ingestion of contaminated prey. Exposure to contaminants could result in lethal or sublethal effects, possibly resulting in reduced productivity or mortality of exposed individuals. Carcinogenic substances could cause genetic or organ damage resulting in sterility, reduced productivity, or reduced fitness among progeny. Little information is available on the effects of contaminants on delta smelt (Brooks *et al.* 2012) and the effects may be difficult to detect. DWR proposes to minimize risks by implementing BMPs and a Spill Response Plan as stated in the AMMs.

Underwater Noise and Vibrations

Construction noise, vibration, and increased human activity may interfere with normal behavior, including feeding, sheltering, and other essential behaviors of delta smelt. Intolerable levels of disturbance may force individuals from suitable habitat cover and subject them to predation that otherwise would not occur. However, given the delta smelt's seasonal to transient use of the locations where the geotechnical explorations will occur, it is expected that rearing juveniles will be in low numbers in the identified areas, resulting in an overall low number of individuals injured or killed.

Disturbance or Alteration to Rearing and Spawning Habitat

Geotechnical exploration activities in open water may affect habitat through suspension and deposition of sediment throughout the water column and onto nearby spawning substrates,

primarily when installing and removing the casing. As a result, potential spawning substrates may be buried or altered by suspended sediment. It is not yet known whether any of the geotechnical boring sites will occur over spawning habitat. For sites that will occur within spawning habitat, effects are expected to be low based on the small disturbance footprints and nature of disturbance resulting from installation and removal of the casings, and the general lack of sandy substrates at the proposed geotechnical exploration sites.

Population-level

Due to the anticipated low numbers of individuals that will be exposed to the geotechnical explorations due to the in-water work restrictions and the locations of the sites, it is expected that there will be very low effects to the overall population.

9.2.2.1.2 Barge Landings and Barge Trips

Effects to Individuals and the Population

Individual-level

The overall exposure of delta smelt to activities related to construction of the barge landings is expected to be minimal. Adverse effects to delta smelt will be difficult to detect due to the delta smelt's small size and rarity. Work has been proposed to be conducted during an in-water work window intended to minimize exposure and avoid the seasonal and transient use by delta smelt of the locations where barge landing locations are identified.

Injury or Mortality from Heavy Equipment

To minimize the adverse effects to delta smelt, the timing of the in-water construction activities, including barge landing construction (July 1 – August 31), will avoid direct effects to migrating adults, incubation (*i.e.*, eggs/embryos), and larval transport phases. During the in-water work window, juvenile delta smelt will be rearing in the action area during the summer and fall months (approximately July – December). However, historical survey data indicate that most of the delta smelt population is distributed away from the proposed construction sites during the proposed July through August work window. Since juvenile delta smelt typically rear downstream of the proposed barge landing locations in the summer and fall, it is expected that there will be a low probability of delta smelt being injured or killed by in-water construction activities, such as pile driving or riprapping. Additionally, there is no scientific evidence that delta smelt have been injured or killed by propeller strikes from barge traffic, presumably due to their small body size and use of various depths within the water column. Water displacement caused by the boat hulls is going to move individuals away from the back of the barges where the propellers are located.

Increased Turbidity and Suspended Sediment

Pile driving, barge operations, and riprapping will be the principal sources of turbidity and suspended sediment during construction of the barge landings. These activities will result in disturbance of the channel bed and banks, resulting in periodic increases in turbidity and suspended sediment in the adjacent waterways. In-water vibratory and impact driving of the sheet piles are expected to generate turbidity plumes that could extend beyond the immediate vicinity of the source piles depending on the direction and velocity of tidal flows. Pile driving will be restricted to the in-water construction window (July 1 – August 31) to avoid the primary periods of delta smelt occurrence near the barge landing sites. Localized increases in turbidity are unlikely to harm delta smelt unless they reach sustained concentrations on the order of 250 NTU.

DWR proposes to develop and implement AMM7, *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (CWF BA 2016, Appendix 3.F, *General Avoidance and Minimization Measures*). Other AMMs that are proposed to avoid or minimize potential turbidity, suspended sediment, and other water quality effects include AMM1, *Worker Awareness Training*; AMM2, *Construction Best Management Practices and Monitoring*; AMM3, *Stormwater Pollution Prevention Plan*; AMM4, *Erosion and Sediment Control Plan*; AMM5, *Spill Prevention, Containment, and Countermeasure Plan*; AMM14, *Hazardous Material Management Plan*; and AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (CWF BA 2016, Appendix 3.F).

Exposure to Contaminants and Disturbance of Contaminated Sediments

Work has been proposed to be conducted during an in-water work window intended to minimize exposure to contaminants. Contaminants may enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from construction sites. Because the barge landings will be constructed on Delta waterways adjacent to major agricultural islands, these sites are more likely to contain agricultural-related toxins such as copper and organochlorine pesticides. Sediments act as a source of contaminant exposure to delta smelt both directly and indirectly through contamination of prey. The resuspension of contaminated sediments may have adverse effects on delta smelt that encounter sediment plumes or come into contact with deposited or newly exposed sediment from contaminant exposure.

Delta smelt using these areas could be exposed to contaminants that are present at the site. Exposure pathways could include respiration, dermal contact, direct ingestion, or ingestion of contaminated food source. Exposure to contaminants could cause short- or long-term morbidity, possibly resulting in mortality or reduced fitness. Little information is available on the effects of contaminants on delta smelt and the effects may be difficult to detect (Brooks *et al.* 2012). DWR proposes to minimize these risks by implementing BMPs and a Spill Response Plan as stated in the AMMs.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*, AMM6, *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material*. These measures include the preparation and implementation of a preconstruction sampling and analysis plan to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (e.g., silt curtains) to achieve compliance with existing Basin Plan objectives will be important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

Underwater Noise and Vibrations

Impact pile driving at the barge landing sites will potentially produce underwater noise levels of sufficient intensity and duration to cause injury to delta smelt. Currently, it is estimated that each barge landing will require vibratory and/or impact driving of 107 steel pipe piles (24-inch diameter) to construct the dock and mooring facilities. Based on the concurrent operation of 4 impact pile drivers at each site and an estimated installation rate of 60 piles per day, pile driving noise is expected to occur over a period of 2 days at each barge landing.

Based on the general timing and abundance of delta smelt in the north, east, and south Delta, restriction of pile driving activities to July 1 – August 31 will essentially eliminate the potential for exposure of delta smelt to pile driving noise during barge landing construction. In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (CWF BA 2016, Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9, *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when delta smelt may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and corrective actions that will be taken should the thresholds be exceeded. These measures will be reviewed and approved by the Service to ensure the measures will minimize adverse effects to delta smelt.

Increased Risk of Predation

Larvae, juveniles, and adults may be subjected to an elevated risk of predation as they pass the barge landing sites, because of the presence of in-water and overwater structures and the loss of overall channel complexity caused by the removal of shallow, low-velocity nearshore areas. The presence of in-water and overwater structures (sheet pile wall, floating docks, piles, and vessels) provides shade and cover that may attract certain predatory fish species (e.g., silversides, striped bass, largemouth bass, Sacramento pikeminnow) and increase their ability to ambush prey, such

as delta smelt. These structures may also increase predation opportunities on delta smelt for piscivorous birds (*e.g.*, gulls, terns, cormorants) by providing perch sites immediately adjacent to open water. Although it is believed that low numbers of delta smelt are currently using this area and therefore, low numbers of individuals would be exposed to increased risk of predation that may result in injury or mortality.

Loss or Degradation of Habitat

Construction of the barge landings will result in temporary to permanent losses or alteration of aquatic habitat in several locations: Snodgrass Slough north of Twin Cities Road (adjacent to proposed IF), Little Potato Slough (Bouldin Island south), San Joaquin River (Venice Island south), San Joaquin River (Mandeville Island east at junction with Middle River), Middle River (Bacon Island north), Middle River (Victoria Island northwest), and Old River (junction with West Canal at CCF). Permanent effects will occur to shallow water habitat and, depending on exact location, associated riparian and wetland habitats that may be used during adult migration or by larvae during the spring.

With implementation of the proposed water quality and sound abatement and control AMMs, in-water construction activities will result in temporary, localized increases in turbidity, suspended sediment, noise, and vibrations in the vicinity of construction sites, but these parameters are expected to return to baseline levels following cessation of construction activities and will not result in long-term effects on aquatic habitat or water quality. Historical survey data indicate that juveniles rear downstream of the proposed barge landing locations in the summer and fall; therefore, juveniles are not expected to be affected by temporary alterations to water quality and noise during construction.

Effects to loss of physical habitat can be measured in acres. The Service has defined the shallow water habitat of delta smelt habitat as all water between Mean High High Water (MHHW) and 3-meters below Mean Low Low Water (MLLW). Construction of the barge landings will result in permanent loss of approximately 22.4 acres of shallow water habitat (approximately 3.2 acres per landing) used by delta smelt at various life stages. Because the barge landings will likely be sited in areas with steep, riprapped levees and deep nearshore areas, the habitat potential of these sites for spawning and other ecological functions is low. Consequently, permanent losses or alteration of nearshore habitat resulting from construction of the barge landings will not likely have a significant effect on spawning habitat or its use by spawning adults. During construction, and continuing during operation of the barge landings, the channel banks, bed, and waters adjacent to the dock will be periodically disturbed by propeller wash and scour from barges and tidal action, resulting in minor changes to water depths, benthic substrates, and loss of submerged and emergent vegetation. The effects of the loss of 22.4 acres of delta smelt habitat will be minimized through on-site and/or off-site mitigation.

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to minimize effects to delta smelt and its habitat (CWF BA 2016, Appendix 3.F, *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction,

and, following construction, to restore disturbed areas to preconstruction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. To further minimize adverse effects to aquatic habitat associated with barge traffic, DWR also proposes to implement a *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (CWF BA 2016, Appendix 3.F, *General Avoidance and Minimization Measures*).

Population-level

Historical survey data indicate the delta smelt population is distributed near the LSZ and in the Cache Slough Complex during the proposed in-water work window. Thus, we do not expect there to be any population-level effects to delta smelt as a result of exposure to in-water construction activities of barge landings. Once the barge landings are constructed, there will be a risk of increased predation at the sites that could potentially result in increased mortality of adult delta smelt or their progeny. Although, this effect is likely to be low based on the number of delta smelt present near the barge landing locations from historical survey data and the relative small footprint of the barge landings relative to open water areas in the affected region of the Delta.

Summary

Delta smelt exposure to the in-water work activities will be avoided with the proposed in-water work window. Based on historical survey data, we expect delta smelt to be distributed near the LSZ during construction. From the start of construction to the completion and until the barge landings are removed, increased predation is likely to occur from in-water structures. Construction of the barge landings will result in permanent effects to approximately 22.4 acres of shallow water habitat that includes the footprint of the docks and mooring structures. Implementation of Guiding Principles 3 and 4, as stated in Section 6.1 within *Description of the Proposed Action* and 9.2.2.2.1 *Framework for the Programmatic Consultation*, are intended to promote turbidity and restore, create, or enhance spawning habitat conditions through commitments made in the CWF PA and through actions described in the Delta Smelt Resiliency Strategy. These Guiding Principles are intended to minimize adverse effects to delta smelt from barge landing construction and other CWF activities. Reclamation and DWR have proposed to mitigate for the permanent loss of shallow water habitat due to construction by restoring 1,827.7 acres of shallow water habitat. Reclamation and DWR have also proposed to develop a sediment reintroduction plan, as described in the CWF BA, to specifically address spawning habitat needs for delta smelt, including the potential for a recurring sediment placement program to maintain sites for the duration of the PA's long-term effects.

9.2.2.1.3 North Delta Diversions

Construction activities that could potentially affect delta smelt include the following in-water activities: cofferdam installation and removal, levee clearing and grubbing, riprap placement, dredging, and barge traffic. In-water construction or work activities are defined here as activities

occurring within the active channel of the river (*e.g.*, at waterline, in water column, on riverbed, or along river shoreline). All other sediment-disturbing activities associated with construction of the NDD and associated facilities, including construction of the sedimentation basins, will be isolated from the Sacramento River and will use appropriate BMPs and AMMs to avoid or minimize the discharge of sediment to the river. DWR has proposed to minimize effects to delta smelt by conducting all in-water work between June 1 and October 31, whereas pile driving will be limited to June 15 through September 15 within that broader work window. Implementation of Guiding Principles 3 and 4, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for the Programmatic Consultation*, are intended to promote turbidity and restore, create, or enhance spawning habitat conditions. These Guiding Principles are intended to minimize adverse effects to delta smelt from NDD construction and other CWF activities and establish a framework for developing future actions consistent with this BiOp.

Effects to Individuals and the Population

Individual-level

In-water construction activities (June 1 – October 31) will avoid the adult migration season and minimize exposure to the adult spawning, incubation (*i.e.*, eggs/embryos), and larval transport phases. Infrequent detection of larger juveniles in beach seine surveys suggests that the Sacramento River serves as a spawning ground and not as a nursery ground (see *Status of the Species at Proposed Action Area Preconstruction and Construction Sites*). Therefore, since juveniles nearly always rear downstream of the proposed intake sites in the summer and fall, few if any will be exposed to the proposed in-water work activities.

Contact with Heavy Equipment or Materials

Adult Spawners (February – June)

In years when air temperatures are cool during the spring, water temperatures likewise remain cool allowing longer spawning seasons (*e.g.*, June instead of May). Given the in-water work window proposed (June 1 – October 31), localized spawning may be impaired depending on what temperature conditions are like when the first year of construction occurs. As previously stated above, very low numbers of delta smelt will be exposed to the in-water work. Although adults are expected to move away from active construction areas, it is assumed there is a potential for injury or mortality whenever heavy equipment or materials are operated or placed in open water.

Eggs and Embryos (Spring: ~ March – June)

Spawning habitat within the footprint of the three intakes is degraded and of low quality. Much of the edge habitat has been ripped and contains only a sparse amount of sandy beaches. Based on the lack of extensive sandy beaches and expected low use and avoidance behavior by spawning adults during in-water construction activities, there is little risk of injury or mortality to

eggs or embryos. However, any eggs or embryos that remain on the east river bank at the construction sites would not be able to escape once construction work commences.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

During the first year of NDD construction, there is potential for adult delta smelt to migrate upstream of the proposed construction areas prior to construction and spawn upstream of where construction work will commence. If that occurs, late spawned larvae or young juveniles being transported downstream could be exposed to in-water work activities. Although the potential for exposure is low, delta smelt larvae and young juveniles may be particularly vulnerable to injury or mortality because their small size limits their ability to escape and their need to pass downstream to survive could make them vulnerable to in-water noise if pile driving occurs during June of that first year of NDD construction. For those years following the cofferdam installation, the Service anticipates that very few or no delta smelt will be able to ascend the river beyond the construction sites. As a result, there should no longer be impacts to offspring. Future Service-approved monitoring studies will investigate the degree to which the NDD construction sites and fish screens act as a migration impediment to delta smelt.

Increased Turbidity and Suspended Sediment

Construction activities within the footprint of the NDD that disturb the riverbed and banks may temporarily increase turbidity and suspended sediment levels in the Sacramento River. These activities include: cofferdam installation and removal; levee clearing and grading; riprap placement; dredging; and barge traffic. These activities will be restricted to the proposed in-water construction window of June 1 through October 31, when delta smelt are least likely to be present in the area. In addition to minimizing effects to delta smelt by limiting activities to occurring within the in-water work window, additional AMMs are proposed to avoid or minimize effects due to increases in turbidity and suspended sediment levels on water quality and direct and indirect effects to delta smelt resulting from sediment-disturbing activities. Those AMMs include the following: AMM1, *Worker Awareness Training*; AMM2, *Construction Best Management Practices and Monitoring*; AMM3, *Stormwater Pollution Prevention Plan*; AMM4, *Erosion and Sediment Control Plan*; AMM5, *Spill Prevention, Containment, and Countermeasure Plan*; AMM14, *Hazardous Material Management Plan*; AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*; and AMM7, *Barge Operations Plan* (CWF BA 2016, Appendix 3.F, *General Avoidance and Minimization Measures*).

Any delta smelt present could be harassed, harmed, or killed by construction equipment, noise, or siltation and impaired water quality. The use of silt trapping devices during all in-water work, where feasible, could minimize the effects on delta smelt caused by siltation and impaired water quality. All other sediment-disturbing activities associated with construction of the NDD, including construction of the sedimentation basins, will be isolated from the Sacramento River and will not result in the discharge of sediment to the river with implementation of the proposed AMMs and BMPs related to off-bank (land-based) construction activities. There is a potential for increased erosion and mobilization of sediment runoff from disturbed levee surfaces; however,

with the implementation of the proposed erosion and sediment control measures (AMM4) and other BMPs to ensure the effectiveness of these measures (AMM2, *Construction Best Management Practices and Monitoring*), no adverse water quality effects are anticipated to delta smelt and its habitat from these land-based activities.

Adult Spawners (February – June)

During cofferdam installation, levee clearing and grubbing, riprap placement, and barge traffic, turbidity and suspended sediment levels in the river are anticipated to exceed ambient levels in the immediate vicinity of these activities. Increases in turbidity and suspended sediment levels will be temporary and localized sediment plumes are unlikely to reach levels causing direct injury or mortality to delta smelt.

Turbidity plumes may extend several hundred feet downstream of construction activities. NMFS (2008) reviewed observations of turbidity plumes during installation of riprap for bank protection projects along the Sacramento River and concluded that visible plumes are expected to be limited to only a portion of the channel width, extend no more than 1,000 ft downstream, and dissipate within hours of cessation of in-water activities. Based on these observations, NMFS concluded that such activities could result in turbidity levels exceeding 25–75 NTUs. Turbidity in this range is in the feeding and physiological optimum for delta smelt (Hasenbein *et al.* 2013, 2016) and therefore should not cause harm to individuals. However, under the assumption that there could be some effect to the substrate of habitat up to 1,000 ft downstream from each intake, this will result in 1.9 acres of impact to shallow water habitat (which is included in the overall 5.6 acres of shallow water habitat impact from the NDD footprint).

Increases in suspended sediment during in-water construction activities may result in localized sediment deposition in the vicinity of the proposed intakes, degrading potential spawning habitat of delta smelt by burying suitable spawning substrates. The Sacramento River in the vicinity of the proposed intake sites consists of mostly low quality spawning habitat due to levees that are dominated by steep slopes, existing riprap, and a lack of sandy substrates. The effects of the permanent loss of downstream shallow water habitat from multiple years of daily in-water construction will be mitigated by the preservation, creation, or restoration of shallow water habitat lost at the amount identified in the *Description of the Proposed Action* and CWF BA *BiOp Resolution Log*, prior to impact, in accordance with the proposed conservation measure by DWR.

Eggs and Embryos (Spring: ~ March – June)

Delta smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure is very low, individual eggs could be subject to burial by the deposition of suspended sediment generated by in-water construction activities. However, only eggs and embryos from late spawners would be subject to burial.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

During the first year of NDD construction, delta smelt larvae and young juveniles may still be in the vicinity of the in-water construction activities during their downstream transport. However, implementation of the proposed pollution prevention, erosion and sediment control, and barge traffic AMMs will prevent local turbidity from reaching harmful levels (*i.e.*, > 80 to 100 NTUs).

Exposure to Contaminants and Disturbance of Contaminated Sediments

Contaminants may enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from the installation and subsequent partial removal of the sheet pile cofferdams. Sediments act as a sink or source of contaminant exposure depending on local hydrologic conditions, habitat type, and frequency of disturbance. Persistent chemicals that have been introduced into the aquatic environment will often bind to sediment particles, with most organic and inorganic anthropogenic chemicals and waste materials accumulating in sediment (Ingersoll *et al.* 1995). Thus, resuspension of contaminated sediments may impact delta smelt that encounter sediment plumes or come into contact with deposited or newly exposed sediment. Suspended sediment can also adversely affect delta smelt by causing localized increases in chemical oxygen demand in waters in or near plumes. These toxins could have an immediate or delayed lethal or sub-lethal effect on various life stages of delta smelt and may also affect the reproductive success. Submerged aquatic vegetation may also be negatively affected by the use of persistent herbicides. The use of silt trapping devices during the in-water work, where feasible, will minimize the effects on delta smelt caused by toxic sediments.

The proposed intake sites are downstream of the City of Sacramento where sediments have been affected by historical and current urban discharges from the city. No information on sediment contaminants at these sites is currently available. Metals, polychlorinated biphenyls (PCBs), and hydrocarbons (typically oil and grease) are common urban contaminants that are introduced to aquatic systems via nonpoint-source stormwater drainage, industrial discharges, and municipal wastewater discharges. Many of these contaminants readily adhere to sediment particles and tend to settle out of solution relatively close to the primary source of contaminants. PCBs are persistent, adsorb to soil and organic matter, and accumulate in the food web. Lead and other metals also will adhere to particulates and can bioaccumulate to levels sufficient to cause adverse biological effects. Mercury is also present in the Sacramento River system and could be sequestered in riverbed sediments. Hydrocarbons biodegrade over time in an aqueous environment and do not tend to bioaccumulate or persist in aquatic systems.

Like pile driving, dredging also has the potential to release contaminants from disturbed sediments into the water column during construction and maintenance dredging at the proposed intakes. Current estimates indicate the total dredging and channel disturbance will affect 12.1 acres of the riverbed adjacent to the cofferdams at the NDD. Measured sediment plumes from hydraulic dredging operations (Hayes *et al.* 2000) suggest that less than 0.1% of disturbed sediments and associated contaminants will likely be re-suspended during cutterhead dredging operations. In sediments, only a small fraction of the total amount of heavy metals and organic contaminants are dissolved. In the case of heavy metals, releases during dredging may be largely

due to the resuspension of fine particles from which the contaminants may be desorbed, and in the case of organic contaminants, most of the chemicals released into the dissolved phase will be bound to dissolved organic matter.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under AMM6, *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material*, in CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*. These measures include the preparation and implementation of a preconstruction sampling and analysis plan to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (*e.g.*, silt curtains) to achieve compliance with existing Basin Plan objectives will be important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

Adult Spawners (February – June)

Exposure of delta smelt to contaminants as a result of spills or sediment disturbance can cause effects that range from physiological stress, potentially resulting in delayed effects on growth, survival, and reproductive success to direct mortality (acute toxicity) depending on the concentration, toxicity, solubility, bioavailability, and duration of exposure, as well as the sensitivity of the exposed organisms (Connon *et al.* 2009; Connon *et al.* 2011a, b; Jeffries *et al.* 2015).

Based on the timing of in-water construction activities (June 1 – October 31), late spawning adults in the vicinity of the NDD in June may be subject to direct exposure from a potential contaminant spill or sediment-borne contaminants (*i.e.*, through exposure to turbidity plumes). Such an exposure may or may not be of a magnitude that causes harm. Further, implementation of the proposed pollution prevention and erosion and sediment control AMMs will minimize contaminant exposure risks.

Eggs and Embryos (Spring: ~ March – June)

Delta smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although exposure of eggs or embryos is expected to be minimal, individual eggs could be damaged or die if directly exposed to contaminant spills or sediment-borne contaminants during construction. Implementation of the proposed pollution prevention and erosion and sediment control AMMs will minimize this risk throughout the construction period.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

Individual larvae and young juveniles may be injured or killed by direct exposure to contaminant spills or sediment-borne contaminants during construction of the intakes during the downstream migration. It is believed that low numbers of delta smelt are currently using this area and therefore, low numbers of individuals would be exposed to increased contaminant levels that may result in injury or mortality. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs will minimize this risk throughout the construction period.

Underwater Noise and Vibrations

During construction of the NDD, activities that are likely to generate underwater noise include pile driving, riprap placement, dredging, and barge traffic. Pile driving poses the greatest risk to delta smelt, because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Therefore, DWR has proposed to further minimize effects to delta smelt by limiting pile driving in-water work to June 15 through September 15 within that broader work window of June 1 to October 31. Other activities such as riprap placement, dredging, and barge traffic generally produce more continuous, lower energy sounds below the thresholds associated with direct injury, but may cause avoidance behavior (*i.e.*, cause delta smelt to detour from the area) or temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

During NDD construction, underwater noise levels of sufficient intensity to cause direct injury or mortality of fish could occur over a period of 12-42 days during the proposed in-water work period (June 15-September 15) for up to 2 years at each intake location. Restriction of pile driving activities in or near open water in the Sacramento River from June 15 through September 15 will minimize the exposure of delta smelt to potentially harmful underwater noise because most individuals will have left the area by June (see Figure 9.2.1.2-4). In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (see CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9, *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory methods or other non-impact driving methods (*e.g.*, drill-shaft methods) whenever possible, to install the cofferdam sheet piles and foundation piles. The degree to which vibratory and non-impact driving methods can be performed is uncertain at this time (due to uncertain geologic conditions at the proposed intake sites) although reasonable assumptions are applied to sheet pile installation in the following analysis. If impact pile driving is required, DWR, in coordination with the Service, NMFS, and CDFW, will evaluate the feasibility of other protective measures including dewatering, physical devices (*e.g.*, bubble curtains), and operational measures (*e.g.*, restricting pile driving to specific times of the day) to limit the intensity and duration of underwater noise levels when delta smelt and/or other listed fish species may be present. Coordination, implementation, and monitoring of these measures will be performed in accordance with the underwater sound control and abatement plan, which includes

hydroacoustic monitoring to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and corrective actions to be taken should the thresholds be exceeded. These measures may include additional physical or operational measures to further limit the magnitude and/or duration of underwater noise levels.

Adult Spawners (February – June)

Restricting pile driving to June 15 – September 15 will avoid most of the delta smelt spawning season, although there is potential for exposure of late spawning adults in June. In general, the effects of pile driving noise on fish may cause fish to swim away from the construction site, may cause physiological stress, or in more extreme cases temporary or permanent hearing loss, organ tissue damage, or mortality of any fish located near a pile strike. Factors that influence the magnitude of these potential effects include life stage and size of fish; type and size of pile and hammer; frequency and duration of pile driving; site characteristics (e.g., depth); and distance of fish from the source. In delta smelt and most other teleost fish, the presence of a swim bladder to maintain buoyancy increases their vulnerability to underwater noise (Hastings and Popper 2005). Sublethal effects of elevated noise include damage to hearing organs that may temporarily affect a delta smelt's swimming ability and hearing sensitivity, which in turn may reduce their ability to detect predators. Non-injurious levels of underwater noise may also startle the fish which can increase vulnerability to predation or attract fish into disturbed areas from suspended prey items in with the sediment.

To quantify the level of sound expected to cause harassment and harm, the Fisheries Hydroacoustic Working Group, an interagency working group that includes the Service, has established interim criteria for evaluating underwater noise effects from pile driving on fish. These criteria are defined in the document entitled "*Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities*", dated June 12, 2008 (Fisheries Hydroacoustic Working Group 2008). This agreement identifies dual interim criteria that represent the acoustic thresholds associated with the onset of physiological impairment in fish that is suggestive of injury resulting from pile driving noise (Fisheries Hydroacoustic Working Group 2008). The dual criteria for impact pile driving are (1) 206 decibels (dB) for peak sound pressure level (SPL), and (2) 187 dB for cumulative sound exposure level (SEL) for fish larger than 2 grams, and 183 dB SEL for fish smaller than 2 grams (Table 9.2.2.1.3-1). The peak SPL threshold is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL threshold is considered the total amount of acoustic energy that a fish can receive from single or multiple strikes without injury. The cumulative SEL threshold is based on the total daily exposure of a fish to noise from sources that are discontinuous (in this case, noise that occurs up to 12 hours a day, with 12 hours between exposures). This assumes that a fish is able to recover from any previously incurred effects during this 12-hour period. These criteria relate to impact pile driving only. Vibratory pile driving is generally accepted as an effective measure for minimizing or eliminating injury of fish from pile driving. Although there has been no formal agreement on a "behavioral" threshold, NMFS uses 150 dB-root mean square (rms) as their threshold for adverse effects on fish behavior.

Table 9.2.2.1.3-1. Interim criteria for injury to fish from pile driving activities.

Interim Criteria	Agreement in Principle
Peak Sound Pressure Level (SPL)	206 dB re: 1 μ Pa (for all sizes of fish)
Cumulative Sound Exposure Level (SEL)	187 dB re: 1 μ Pa ² -sec—for fish size \geq 2 grams 183 dB re: 1 μ Pa ² -sec—for fish size $<$ 2 grams

Fish smaller than 2 grams are more sensitive to underwater noise than larger individuals (Table 9.2.2.1.3-1). Larvae and young juvenile delta smelt are generally smaller than 2 grams, while adults average 2 to 3 grams (Foott and Bigelow 2010). Because some adults are less than 2 grams, the lower injury threshold (183 dB) was applied to all life stages. The interim criteria were set to be conservatively protective of delta smelt and NMFS species.

The potential for injury of fish from exposure to pile driving sounds was evaluated using a spreadsheet model developed by NMFS to calculate the distances from a pile that the peak and cumulative sound criteria travel (available at: <http://www.dot.ca.gov/hq/env/bio/files/NMFS%20Pile%20Driving%20Calculations.xls>). These distances define the area in which the criteria are expected to be exceeded as a result of impact pile driving. The NMFS spreadsheet calculates these distances based on estimates of the single-strike sound levels for each pile type (measured at 10 meters from the pile) and the rate at which sound attenuates with distance. In the following analysis, the standard sound attenuation rate of 4.5 dB per doubling of distance was used in the absence of other data. To account for the exposure of fish to multiple pile driving strikes, the model computes a cumulative SEL for multiple strikes based on the single-strike SEL and the number of strikes per day or pile driving event. The NMFS spreadsheet also employs the concept of “effective quiet”. This assumes that cumulative exposure of fish to pile driving sounds of less than 150 dB SEL does not result in injury.

Other sources of in-water noise include generator and engine vibration transmitted through the hulls of work barges and associated vessels, and dredge equipment. Noise levels produced by these sources typically are less than those associated with vibratory pile driving and are likely to be comparable to ambient noise conditions in the vicinity of the intakes caused by traffic, boats, water skiers, etc. For routine vessel traffic, these noise levels typically range from peak levels of 160 to 190 dB at a range of 10 meters, depending on vessel size (Thomsen *et al.* 2009). Vessels will be traveling along haul routes from established barge landings in Stockton, Antioch, and San Francisco to the newly constructed barge landing locations identified in the *BiOp Resolution Log*. Dredge equipment noise will vary depending on equipment type. For example, a hydraulic cutterhead dredge working in the SDWSC produced noise levels of around 152 to 157 dB at 1 meter from the source (Reine and Dickerson 2014). Removal of pilings or other underwater structures could involve use of vibratory methods. This could generate sounds that could cause avoidance behavior of any delta smelt present. However, the noise levels generated by vibratory driving do not approach the peak or cumulative sound criteria outlined above.

Insufficient data are currently available to support the establishment of a noise threshold that stresses fish enough to change their behavior in a deleterious way (Popper *et al.* 2006). NMFS

generally assumes that a noise level of 150 dB root mean square (RMS) is an appropriate threshold. NMFS acknowledges this threshold is uncertain, but believes 150 dB root mean square (RMS) is effective in minimizing effects.

Table 9.2.2.1.3-2 reports the estimates of the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds based on application of the NMFS spreadsheet model and the assumptions presented in CWF BA Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*. This analysis considers only those pile driving activities that could generate noise levels high enough to exceed the interim injury thresholds. These activities include impact pile driving in open water, inside cofferdams adjacent to open water, or on land within 200 ft of open water. For cofferdam sheet piles, it is assumed that approximately 70% of the length of each pile can be driven using vibratory pile driving, with impact driving used to finalize pile placement. For the intake structure foundation piles, the current design assumes the use of impact pile driving only. However, some degree of attenuation is expected assuming that the cofferdams can be fully dewatered. Therefore, predictions are shown for two scenarios, one in which dewatering results in a 5 dB reduction in reference noise levels, and one in which no attenuation is possible (no dewatering or other forms of attenuation). All computed distances over which pile driving sounds are expected to exceed the injury and behavioral thresholds assume an unimpeded sound propagation path. However, site conditions such as major channel bends and other in-water structures can reduce these distances by impeding the propagation of underwater sound waves.

Table 9.2.2.1.3-2. Extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds from NDD construction-related activities.

Facility or Structure	Distance to 206 dB SPL Injury Threshold (ft)	Distance to Cumulative 187 dB SEL Injury Threshold ^{1,2} (ft)	Distance to 150 dB RMS Behavioral Threshold d ² (ft)	Construction Season	Timing of Pile Driving	Duration of Pile Driving (days)
Intake 2						
Cofferdam	30	2,814	13,058	Year 8	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 9	Jun–Oct	19
Foundation (with attenuation)	20	1,522	15,226	Year 9	June–Oct	19
Intake 3						
Cofferdam	30	2,814	13,058	Year 7	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 8	Jun–Oct	14
Foundation (with attenuation)	20	1,522	15,226	Year 8	June–Oct	14
Intake 5						
Cofferdam	30	2,814	13,058	Year 5	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 6	Jun–Oct	19
Foundation (with attenuation)	20	1,522	15,226	Year 6	June–Oct	19
¹ Computed distances to injury thresholds are governed by the distance to “effective quiet” (150 dB SEL). Calculation assumes that single strike SELs <150 dB do not accumulate to cause injury. Accordingly, once the distance to the cumulative injury threshold exceeds the distance to effective quiet, increasing the number of strikes does not increase the presumed injury distance. ² Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.						

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 30 ft of the cofferdam sheet piles and 20–46 ft of the intake foundation piles, depending on whether cofferdams can be dewatered (Table 9.2.2.1.3-2).

Based on a cumulative (daily) threshold of 187 dB SEL, the risk of injury is calculated to extend up to 5,628 ft ($2,814 \times 2$)²² during installation of the cofferdams and 6,560 ft ($3,280 \times 2$) during

²² The radius was doubled to determine the diameter of noise effects to delta smelt.

installation of the foundation piles (3,044 ft if the cofferdams can be dewatered) assuming an unimpeded propagation path.²³ It is likely that bends in the river will attenuate sound faster than these predictions indicate, so these estimates likely reflect maximum potential for impacts. The predictions in Table 9.2.2.1.3-2 apply to one intake location; the current construction schedule indicates that pile driving will occur at only one intake in a given year, except for Year 8 in which cofferdam installation at Intake 2 may coincide with foundation pile installation at intake 3 (CWF BA 2016, Appendix 3.D, *Construction Schedule for the Proposed Action*). In this case, there will be no overlap in the potential noise impact areas, although delta smelt moving through the action area could be exposed to pile driving noise over two reaches totaling 12,188 feet. Based on the duration of pile driving, such conditions could occur for up to 14 days based on the duration of foundation pile installation.

The potential for behavioral effects will exist beyond the distances associated with potential injury. Based on a threshold of 150 dB RMS, the potential for behavioral effects is calculated to extend up to 13,058 ft (2.5 miles) from the cofferdam sheet pile installation, and 32,800 ft (6.2 miles) from the intake foundation pile installation (15,226 ft or 2.9 miles away if the cofferdams can be dewatered). These estimates assume an unimpeded propagation path. However, the extent of noise levels exceeding the injury and behavioral thresholds will be constrained to varying degrees by major channel bends that range from approximately 1,500 to 12,000 ft away from each intake facility. Although it is believed that low numbers of delta smelt are currently using this area and therefore, low numbers of individuals would be exposed to elevated noise levels that may result in injury or mortality.

For each intake facility, the current construction schedule indicates that cofferdam sheet piles will be installed over a period of 42 days at each intake location within the proposed in-water construction season followed by installation of the intake foundation piles over a period of 14 to 19 days during the following season.

Eggs and Embryos (Spring: ~ March – June)

Delta smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). There is limited research on effects of noise on delta smelt eggs; however, the potential for exposure is low due to the work window. Prolonged exposure to pile driving noise may reduce survival, development, or viability of any individual eggs in the vicinity of the intake sites (Banner and Hyatt 1973).

²³ Based on the estimated number of pile strikes per day, the computed distances to the injury thresholds are governed by the distance to “effective quiet” (150 dB SEL).

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

During June of the first year of construction, delta smelt larvae and young juveniles originating from upstream spawning areas may encounter pile driving noise during downstream movement to estuarine rearing areas. Although the exposure potential is low, any larval delta smelt passing the intakes during impact pile driving will be unable to avoid exposure to pile driving noise and therefore could be injured or killed depending on their proximity to the source piles and the duration of exposure.

Stranding

If present, delta smelt could be harassed, displaced, or die during construction of the riprap and sheet pile cofferdam. Installation of cofferdams to isolate the construction areas for the proposed intake sites has the potential to strand delta smelt, resulting in direct mortality from dewatering, dredging, and pile driving within the enclosed areas of the channel. Adults are at less risk than younger delta smelt, which are more vulnerable to stranding due to their limited ability to swim away and are more susceptible to being entrained.

To minimize entrapment risk and the number of delta smelt subject to capture and handling during fish rescue and salvage operations, cofferdam construction will be limited to the proposed in-water construction period (June 1–October 31) with pile driving proposed to occur June 15–September 15 of that broader work window) to avoid the peak abundance of adults, larvae, and young juveniles in the north Delta. The effect of stranding on delta smelt will be minimized by rescuing/salvaging any delta smelt stranded behind the cofferdam prior to dewatering. DWR will prepare and submit a fish rescue and salvage plan²⁴ (see CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*, AMM8, *Fish Rescue and Salvage Plan*) to the fish and wildlife agencies (NMFS, Service, CDFW) for review and approval prior to implementation. Due to the delta smelt's sensitive nature, it is likely that any delta smelt salvaged from behind the cofferdam will die from the fish capture methods and handling. Therefore, the efficacy of this minimization measure is considered low. The proposed in-water work window is the most effective measure to reduce stranding.

Adult Spawners (February – June)

Although present in very low numbers, spawning adults may be present in the vicinity of the NDD in June and subject to stranding behind the cofferdams. Adults are expected to move away

²⁴ The fish rescue and salvage plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that will apply to all in-water activities with the potential to entrap delta smelt. All fish rescue and salvage operations will be conducted under the guidance of a qualified Service-approved fish biologist. The Service-approved biologist, in consultation with CDFW and NMFS, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing if Service-approved.

from active construction occurring, but some risk of stranding will exist as long as the interior of the cofferdam is accessible to delta smelt. Fish rescue and salvage activities using typical fish collection methods can result in injury or mortality to delta smelt. Given the appropriate training, some level of survival is possible. However, injury or mortality may still occur because of varying degrees of effectiveness with the collection methods and potential stress and injury associated with various capture and handling methods.

Eggs and Embryos

Based on the low utilization and expected avoidance of the intake sites by spawning adults, there is low to no risk of stranding delta smelt eggs or embryos.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

Although the potential for exposure is very low, delta smelt larvae and young juveniles may be particularly vulnerable to stranding because of their limited swimming abilities and potential entrainment in open cofferdams. In addition, conventional fish collection methods are less effective and more likely to cause injury or death of these life stages compared to larger juveniles or adults. Therefore, it is likely that most if not all of any larvae and young juveniles present will die as a result of stranding.

Increased Risk of Predation

Changes in hydrology will occur due to the placement of the cofferdams, the fish screens, and rock revetment around the new intakes. This could change how delta smelt are able to use this reach of the Sacramento River, blocking migrants and limiting access to the already narrow shoals in this river reach. Riprap and eddies created upstream and downstream of structures like the sheet pile cofferdams or the fish screens are known to attract predatory fish that may prey upon the delta smelt. The creation of deeper, higher-velocity zones adjacent to the cofferdams, additional riprap and fish screens may increase predator ambush habitat, although this will only affect individuals that migrate to the NDD locations. Although it is believed that low numbers of delta smelt are currently using this area and therefore, low numbers of individuals would be exposed to an increased risk of injury or mortality from predation. Additionally, implementation of Guiding Principle 6, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for the Programmatic Consultation*, is intended to improve population-level delta smelt habitat conditions through reductions in non-native invasive species. This Guiding Principle will ensure that as future development of the NDD occurs, minimization of entrainment of predators and other effects of the structures will be incorporated.

Loss, Alteration, and Restricted Access to Habitat

NDD construction will result in permanent loss, alteration, and accessibility of shallow water and open water habitat to migrating and spawning adults, eggs and embryos, and transport of larval and young juveniles. The effects of construction activities on water quality, including turbidity and suspended sediment, and contaminants, were previously discussed above. Implementation of

Guiding Principles 3 and 4, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for the Programmatic Consultation*, are intended to promote turbidity and restore, create, or enhance spawning habitat conditions through commitments made in the CWF PA and through actions described in the Delta Smelt Resiliency Strategy. These Guiding Principles are intended to minimize adverse effects to delta smelt from NDD construction and other CWF activities and establish a framework for developing future actions consistent with this BiOp. DWR has proposed to mitigate effects prior to the impact (see *Description of the Proposed Action*) within their mitigation proposal to restore 1,827.7 acres of shallow water habitat. Reclamation and DWR have also proposed to develop a sediment reintroduction plan, as described in the CWF BA, to specifically address spawning habitat needs for delta smelt, including the potential for a recurring sediment placement program to maintain sites for the duration of the PA's long-term effects.

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to minimize effects to delta smelt (see CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance to aquatic habitat during construction, and, following construction, to restore temporarily disturbed areas to preconstruction conditions. All construction and site restoration BMPs will be subject to a Service-, CDFW-, and NMFS-approved construction and post-construction monitoring plan to ensure their effectiveness. DWR proposes to offset unavoidable, permanent habitat loss from the construction of the proposed intake sites through yet-to-be developed shallow water habitat mitigation, with specific spawning habitat features.

The range of delta smelt extends north of the City of Sacramento; however, recent monitoring suggests that delta smelt only occasionally migrate beyond the extent of designated critical habitat (I Street Bridge; see *Status of the Species*). As a supplement to the CWF BA, the *BiOp Resolution Log* quantified effects (in number of acres) of the restricted access to habitat to the extent of its range (Knights Landing). The Service anticipates that construction of the NDD will result in a contraction of the delta smelt's range precluding access to habitats between Clarksburg and Knights Landing that might otherwise be used more frequently and in greater numbers in the future, especially given the potential for salinity intrusion from current climate change projections or under drought conditions.

Migrating Adults (December – March)

Delta smelt ascending the Sacramento River beyond its confluence with Cache Slough cannot swim against mid-channel velocities for an extended time and use low velocity paths to migrate upstream while also avoiding predation (CWF BA 2016). In downstream locations, vertical and lateral distribution changes have been observed that help fish both move and maintain geographic positions (Bennett *et al.* 2002; Feyrer *et al.* 2013; Bennett and Burau 2015), but these previous studies provide no evidence that delta smelt show affinity to one side of the river or the other when they move on and off shore. The Sacramento River makes 6 major bends between Isleton and Freeport shunting the highest velocity parts of the river cross section back and forth across the channel. In addition to this shifting high velocity water, it seems unlikely that delta smelt could keep swimming up one bank of the river from Isleton to areas upstream because they

would eventually need to avoid a predator or be displaced off the shoreline at night when they lose visual reference and become less active. Both of these phenomena would tend to mix migrating smelt across the shorelines from day to day. Thus, in-water structures of the length proposed by the PA are likely to delay, impede or entirely block upstream migration.

Once constructed, each intake will be a permanent vertical wall extending 1,030-1,404 ft along the east bank of the Sacramento River, creating an impediment to fish passage. During February-May, data indicate that small numbers of adult delta smelt move upstream along the river reach where the intake will be constructed (see *Status of the Species at Proposed Action Area Preconstruction and Construction Sites*). The PTM modeling in the CWF BA suggests that these migrating adults could not ascend the Sacramento River this far changing only their depth in the water column (CWF BA 2016). Therefore, these individuals must consistently remain in lower velocity water near the shore. The anticipated water velocities along the cofferdam faces, and later the fish screens, will be faster than delta smelt can swim against for extended periods of time. Without an immediately adjacent shoreline to provide a velocity refuge, the Service believes this will create an impediment that will prevent individuals from migrating beyond the NDD.

Using December – June Freeport velocity data, the probability that an individual migrating adult delta smelt will successfully pass the lowermost cofferdam or intake structure was estimated to range from 0.071 to 0.072 (CWF BA 2016, Appendix 6A.2). The probability that an individual will pass all three intakes is estimated to be 0.0004²⁵. This analysis suggests that river velocities will almost always be too high for delta smelt to swim the required distance upstream. However, as discussed on page 24 of the *Independent Review Panel Report for the 2016-2017 California WaterFix Aquatic Science Peer Review Phase 2B*, this calculation assumes that any delta smelt surviving past the first fish screen (intake 5) has an undiminished chance of getting past the second fish screen (intake 3), and likewise for the third fish screen (intake 2). Furthermore, the effort that a delta smelt must expend to make its way past any one fish screen will very likely reduce its chance to getting past subsequent fish screens. Thus, the probability of passing the second fish screen is likely to be less than 7.1 or 7.2%, conditional on passing the first fish screen. And the probability of passing the third fish screen, conditional on having to pass the first and second fish screen, is likely to be even smaller. So, the overall probability of passing all three fish screens is almost certainly less than 0.04%, approaching zero. The probability of fish passage past the fish screens could increase when considering the possibility of utilizing both sides of the river bank; however, based on the geography of the river, the bends will force most delta smelt towards the eastern bank where the NDD will be. Also, during high flow periods, the river velocities are higher than the dry year velocities used in the calculations above, which further substantiates that the NDD will create a restriction for upstream migration and spawning.

²⁵ If the probability of passing one intake is approximately 0.07, then the probability of an individual adult delta smelt passing all three intakes is 0.0004 ($0.07 \times 0.07 \times 0.07$) if it remains oriented toward the east river bank.

Adaptive management efforts include monitoring and research which should further inform the effects of the NDD to delta smelt passage (refer to the *Adaptive Management Program*).

The CWF BA analysis of the ability of migrating adult delta smelt to pass the most downstream intake if occurring near the east bank suggested that only a very small percentage (4%) of fish would be expected to do so. If successfully passing one intake and remaining near the east bank, the remaining delta smelt would encounter the other intakes and have to decide whether to try to pass them, with a similarly low probability of success. Whether a delta smelt could migrate upstream past the three intakes would depend on its ability to use lower velocity habitat on the west bank of the river, near the channel bottom, or within the refugia along the intakes. Pre-construction studies are expected to further investigate the potential use of the refugia screen panels by delta smelt. However, at this time we do not consider it likely that delta smelt will intentionally enter the refugia because this is an open water species that does not seek cave-like structures in the wild and is stressed by confined spaces in captivity. In addition, predators (*e.g.*, striped bass, largemouth bass, and catfish) are also likely to use the refuge to escape the high water velocities along the fish screens.

Delta smelt detections along the reach of the proposed intake locations are consistent, but low in shallow water surveys (*e.g.*, beach seines) and even lower for mid-channel trawls. The presence of the intake structures will likely prevent migrating adult delta smelt from continuing past the NDD and result in injury or mortality due to impingement when individuals try to pass them. Few or no individuals may attempt to keep moving upstream along the east bank once they encounter elevated velocities associated with the first diversion. However, delta smelt can currently ascend the river along its east bank. Thus, the loss of low-velocity shoreline and increase in shoreline water velocity along the river's east bank that will occur as a result of installing a cofferdam and constructing the NDD will permanently remove or restrict habitat accessibility because it will alter the capacity of delta smelt to ascend the river. However, low numbers of delta smelt are believed to migrate this far upstream, and therefore NDD construction is only expected to affect a small proportion of the population.

During the in-water construction period, a total of approximately 5.6 acres of shallow water habitat will be permanently removed within the NDD construction footprint. This includes 0.4 acres that will be altered by dredging and barge traffic through changes in channel depths, benthic habitat, cover, and temporary in-water and overwater structure (barges, spud piles) within active work areas adjacent to the proposed intake structure and levee slope. The footprint of the three intake structures, transition walls, and bank protection will result in the permanent loss of approximately 3.2 acres of shallow water habitat. In addition, the 5.6-acre estimate includes potential suspended sediment effects to habitat 1,000 ft downstream of each intake (a total of 1.9 acres of shallow water habitat). Permanent modifications of nearshore habitat due to the presence of these structures will encompass a total of 5,367 ft (1.02 miles) of shoreline. At each intake, between 1.6 and 3.1 acres of open water habitat will be located within the cofferdams during construction.

Table 9.2.2.1.3-3 provides an account of the habitat acres estimated in the *BiOp Resolution Log* to be permanently affected from the permanent removal, alteration, or restricted access by delta

smelt from NDD construction. Construction of the NDD will result in restricted access to 250.6 acres of adult migration and spawning habitat from Intake 5 to the I Street Bridge and another approximately 250 acres to Knights Landing, which is the northern extent of their range.

Table 9.2.2.1.3-3. Quantity of habitat acres²⁶ calculated to be permanently lost from removal, alteration, or restricted access by delta smelt from NDD construction.

Reach	Open Water Habitat	Shallow Water Habitat	Area of Sandy Beach	Sandy Beach Shallow Water Habitat	Designated Delta Smelt Critical Habitat
NDD Intake 5 to I Street Bridge	1,540 acres	250.6 acres	50 acres	36 acres	Yes
I Street Bridge to Knights Landing	1,562 acres	~ 250 acres ²⁷	58.5 acres	~ 42 acres ²⁸	No

This BiOp provides a programmatic analysis of the NDD construction, operations, maintenance, monitoring, and adaptive management. Information on the substrate type and vegetation within the footprints are unknown at this time, but is expected to be developed during subsequent consultation during Phase 2 of the Corps permitting when more information on the final siting and design of the NDD is available. As currently provided, the CWF BA does not provide the full quantity of sandy substrate within the shallow water habitat footprint expected to be affected, except for the area of habitat lost to upstream access. This was estimated through aerial imagery²⁹ (due to low vegetation in the area covering the substrate an estimate was feasible) that is expected to be refined when additional information is available to the Service, prior to impact.

DWR has proposed to mitigate the loss of delta smelt migratory and spawning habitat from NDD construction through a commitment to restore 1,753 acres of shallow water habitat. DWR has proposed to provide mitigation prior to the impact. The compensatory mitigation will consist of newly created or restored sandy beaches of high quality in areas where delta smelt are known to occur, such as Sherman Island, Cache Slough, north Delta, or other areas approved by the Service and CDFW. Mitigation sites within or upstream of the NDD will not be considered

²⁶ Values within the NDD Intake 5 to I Street Bridge reach include the NDD footprints.

²⁷ Estimated from the observed shallow water to open water ratio from NDD Intake 5 to I Street Bridge (*i.e.*, 250:1,540).

²⁸ Estimated from the observed shallow water sandy beach to sandy beach ratio from NDD Intake 5 to I Street Bridge (*i.e.*, 36:50).

²⁹ Based on Google Earth Pro aerial imagery from 4/16/2015 with Freeport flow = 5,490 cfs [DAYFLOW] (refer to *California WaterFix Revised Mitigation Proposal Informing Service Final Biological Opinion* memorandum transmitted from Reclamation and DWR on 05/05/2017 in the *BiOp Resolution Log*).

appropriate for mitigating effects to habitat. DWR proposes to provide shallow water habitat that will be of higher quality and in areas closer to core areas of occurrence (*i.e.*, the ‘North Arc’). The sandy beaches will have appropriate water velocities and depths to maintain the habitat and be accessible to delta smelt for direct use. Water quality conditions must also be suitable for delta smelt (*e.g.*, lack high density aquatic invasive plants that could serve as predator habitat, non-lethal levels of contaminants, and suitable salinity levels). Examples of site-specific areas include, but are not limited to: Sherman Island, lower San Joaquin River (such as San Andreas Shoal and Prisoners Point area), Sutter and Steamboat Sloughs, and waterways within the Cache Slough Complex.

Overall, these changes to the Sacramento River in the vicinity of the proposed intakes will block, delay, or impede adult passage, elevate risk of predation from an increase in predator habitat, and constrain the width of the channel. The Service anticipates that with mitigation included in the PA, effects to migrating adults will be minimized by creation of additional spawning habitat in areas that remain accessible to delta smelt. Additionally, implementation of Guiding Principle 4, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for Programmatic Consultation*, is intended to restore, create, or enhance spawning habitat conditions through mitigation commitments made by the CWF BA and through actions described in the Delta Smelt Resiliency Strategy. This Guiding Principle is intended to minimize adverse effects to spawning habitat and establish a framework for developing future actions consistent with this BiOp.

Adult Spawners (February – June)

Within the footprint of the proposed intake locations, there appears to be little or no sandy substrates that are thought to be preferred by delta smelt for spawning habitat (see *Status of the Species at Proposed Action Area Preconstruction and Construction Sites*). During the site selection process, DWR proposed the placement of the intakes in areas, avoiding, where feasible, large stands of riparian shaded riverine habitat for NMFS species and spawning substrates for delta smelt (BDGP 2013). The proposed intake locations are dominated by steep levee slopes, existing riprap and low quantities of riparian and aquatic vegetation. The permanent loss of nearshore habitat will block, delay, or impede access to upstream sandy beaches and remove low quality spawning habitat. As a result, delta smelt that would have otherwise used this habitat for spawning may seek suitable spawning habitats downstream.

It is unknown if there will be an effect to the spawning success of those individuals that migrate up the Sacramento River and have to redistribute downstream to avoid the construction areas. Predation rates are higher for those individuals that travel further looking for suitable places to spawn. Spawning habitat is not thought to be a limiting factor for delta smelt within the action area, although spawning habitat is limited along the Sacramento River due to historical habitat conversions (*e.g.*, riprapping). These reductions in spawning habitat and changes to spawning behavior will occur in approximately 15 RMs of edgewater with intermittent spawning habitat, typically thought to be areas with sandy substrates with suitable water velocities, from just below the southernmost diversion northward to the I Street Bridge.

Additionally, the three permanent structures will redefine the northern limit of the delta smelt spawning distribution, reducing the northern extent of its range (see *Status of the Species* Figure 9.2.1.1-6), which extends beyond the I Street Bridge. As stated above, NDD construction will block or impede access to 78 acres of spawning habitat from the lowermost NDD to the northern extent of its range along the Sacramento River and its tributaries (see Table 9.2.2.1.3-3 above). Implementation of Guiding Principles 3 and 4, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for the Programmatic Consultation*, are intended to promote turbidity and restore, create, or enhance spawning habitat conditions through commitments made in the CWF PA and through actions described in the Delta Smelt Resiliency Strategy. These Guiding Principles are intended to minimize adverse effects to delta smelt from NDD construction and other CWF activities.

Eggs and Embryos (Spring: ~ March – June)

Available data suggest that currently few individuals utilize the habitats in the vicinity of the proposed NDD for spawning. It is unknown if there will be an effect to the spawning success of delta smelt that migrate up the Sacramento River to spawn and are forced to move back downstream to avoid the high velocity conditions discussed above.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

At this life stage, delta smelt may be subject to predation along the intake sites where construction is proposed to occur. Once installation of the three cofferdams has occurred, it is expected that adult delta smelt will experience restricted access to areas above the cofferdams to spawn. With the anticipated reduction in delta smelt spawning at and north of the cofferdams, it is expected that fewer larval and juvenile offspring will pass back downstream. Overall, there will be a loss in edge water and open water habitat available to larvae and young juveniles for transport in these areas, similarly as it is for migrating adults, adult spawners, and eggs and embryos.

Rearing Juveniles (Summer/Fall: ~ July – December)

Juvenile delta smelt rear downstream of the proposed intakes in the summer and fall and therefore are unlikely to be affected by losses or alteration of habitat in the vicinity of the Sacramento River where the proposed intakes are located.

Population-level

Survey data indicate that most of the delta smelt population is distributed downstream of the proposed intake sites. Adults and larvae have been reported to occur in the north Delta and one adult has been collected as far upstream as Knights Landing (Vincik and Julienne 2012). The results from various surveys and general life history information suggest that the proportion of the population moving through or occupying the area that will be affected by construction of the NDD is low. Further, most individuals use this river reach during the winter and spring migration and spawning periods, rather than during the proposed in-water work period. For example, the

mean densities of delta smelt larvae collected in the vicinity of the proposed intakes during 1991-1994 egg and larval surveys was 4-6% of the mean densities collected downstream of these locations during April and May. The low catches of migrating adults near the proposed intake sites during the construction window are also supported by the DJFMP beach seine data. With the expected low use near the intakes by spawning adults and low contribution to the overall spawning habitat available, there is a low risk on egg and embryo production or survival.

Due to current low population estimates and record low detections of delta smelt in recent years, the individuals remaining in the population are more valuable and susceptible to further reductions in the population. It is possible that the reduction in available migratory and spawning habitat from loss and restricted upstream access will have effects to the overall viable population size. However, the Service has no information on the relative value of individuals originating from or returning to the Sacramento River between Clarksburg and areas upstream to the overall population. Implementation of the proposed future Service-approved monitoring plan as described in the CWF BA and the *Adaptive Management Program* may provide information to better quantify and assess the consequences of restricted upstream passage (CWF BA 2016; *Adaptive Management Program*).

Summary

Delta smelt presence has been established in the Sacramento River where construction is proposed to occur. Only 3 adult delta smelt have been observed during DJFMP beach seine surveys during the in-water work window of June 1 through October 31. This supports our conclusion that there is a low likelihood of exposure to in-water work activities because there are relatively few adult delta smelt using this area.

DWR proposes to construct cofferdams to minimize effects to delta smelt by isolating work areas from fish in the river. If present during the first year of construction of the cofferdams, individual delta smelt (adults, eggs/embryos, larvae, and young juveniles) may experience: direct physical injury or mortality from riprapping and sheet piling, exposure to contaminants from accidental spills and disturbed contaminated sediments, underwater noise, and increased risk of predation. Thereafter, habitat loss becomes an additional effect; once the installation of the cofferdams has been completed, the altered hydrology will impair the upstream migration of delta smelt to upstream spawning habitat, constricting their overall range. The cofferdams will reduce the width of the river channel and eliminate some of the already limited amount of shallow, low-velocity nearshore zone along the east bank of the river.

Construction of the NDD is expected to block, delay, or impede delta smelt access to spawning habitat from the intakes to the northern extent of their range. However, low numbers of delta smelt are believed to migrate this far upstream, and therefore NDD construction is only expected to affect a small proportion of the population. In addition, DWR has proposed compensatory mitigation for the loss of this habitat. We anticipate this habitat restoration will minimize effects to delta smelt from NDD construction.

9.2.2.1.4 Head of Old River Gate

Effects to Individuals and the Population

Individual-level

The timing of the in-water HORG construction activities (August 1 – October 31) will avoid adverse effects to migratory and spawning adults, incubation (*i.e.*, eggs/embryos), and larval transport phases because these life stages do not occur during this time of year. HORG construction is scheduled to occur (August 1–October 31) during juvenile delta smelt rearing (approximately July – December). However, conditions at the HORG are not suitable for juvenile rearing at this time of the year because the water is too warm so we do not expect any individuals to be present at the construction site during the work window. Water temperature will cool during the work window, but delta smelt will not re-occupy this site until after the first winter rains occur in December or January. This seasonal change in the distribution of delta smelt is also addressed in RPA Component 2 of the 2008 Service BiOp, where the action ends June 30th or when the 3-day mean water temperature at CCF reaches 25 degrees Celsius, whichever occurs earlier (Service 2008; see *Status of the Species* and *Status of the Species at Proposed Action Area Preconstruction and Construction Sites*). Therefore, we do not expect there to be any exposure to delta smelt from in-water work activities occurring at the HORG during August 1–October 31.

Increased Risk of Predation

As analyzed in the 2008 Service BiOp, delta smelt and their offspring that migrate into the south Delta within the entrainment footprint are functionally lost to the population due to reverse flows, entrainment and salvage, predation, and degraded habitat conditions, except during the wettest years in the San Joaquin Basin. With the installation of the HORG, there will be an increased risk of predation during the earlier months of the year when delta smelt are present. The cofferdam will constrict the flow to half the channel's width which will increase water velocities. The presence of in-channel cofferdams and the HORG may increase the amount of predatory fish habitat and create hydraulic conditions that improve a predator's ability to prey on delta smelt as they migrate past the site. In its current state, the south Delta almost always has an annual installation of a temporary spring and sometimes fall HOR rock barrier, which poses similar predation concerns. However, the HORG will be a permanent in-water structure. Reclamation and DWR have committed to further engagement with the Service, NMFS, and CDFW during finalization of the design to develop measures to minimize predation and other effects of the structure. Additionally, implementation of Guiding Principle 6, as stated in Section 6.1 within the *Description of the Proposed Action* and 9.2.2.2.1 *Framework for the Programmatic Consultation*, is intended to improve population-level delta smelt habitat conditions through reductions in non-native invasive species. This Guiding Principle will ensure that as future development of the HORG occurs, minimization of entrainment of predators and other effects of the structure will be incorporated.

Loss or Alteration of Habitat

Construction of the HORG will result in permanent impacts to approximately 2.9 acres of shallow water habitat including the footprint of the gate and the channel segments upstream and downstream of the structure that will be affected by dredging. DWR proposes to mitigate unavoidable impacts to delta smelt habitat from construction of the HORG with 8.7 acres of habitat.

Migrating Adults (December – March)

Historically, delta smelt more frequently utilized portions of the San Joaquin River upstream as far south as the City of Mossdale; however, they no longer occur in large numbers at the HOR due primarily to poor water quality and increased temperature, high entrainment risk, and perhaps high predation risk associated with the aquatic weed infestations present throughout much of the south Delta. We base this conclusion on the recent lack of detections in the Mossdale Kodiak trawls, nearby DJFMP beach seines, annual ongoing disturbance from installing a temporary HOR rock barrier, riprapped levees, and denuded habitat.

DWR has proposed to mitigate effects to shallow water habitat from construction of the HORG as described in the *Description of the Proposed Action*. Location of the mitigation is important to the function of the habitat for delta smelt. DWR has proposed to mitigate in areas such as, Sherman Island, Cache Slough, or the north Delta, where we observe higher abundances of delta smelt. The habitat will have the appropriate water velocities and depths to maintain the habitat and be accessible to delta smelt for direct use. In addition, it will have the appropriate water quality conditions in order to be suitable for delta smelt (e.g., lack of man-made predator habitat, non-lethal levels of contaminants, and suitable salinity levels). Given the degraded condition of the habitat within the area of the HORG footprint, habitat being mitigated for at a 3:1 ratio, in areas that are of higher value and quality to delta smelt, will provide an overall greater conservation value to delta smelt in comparison to the habitat that will be disturbed or removed by HORG construction.

Adult Spawners (February – June)

Loss or alteration of aquatic habitat within the footprints of the cofferdams, riprapped banks, and dredged channel areas may reduce the amount of shallow water habitat potentially available to spawning adults. However, this portion of the Old River channel is frequently disturbed by the annual installation of a temporary rock barrier and is dominated by steep levee slopes, riprap, and low quantities of sandy substrates, riparian, and aquatic vegetation (see *Existing Conditions and Previous Consultations in the Action Area*).

Eggs and Embryos (Spring: ~ March – June)

Based on the lack of spawning habitat for delta smelt, the potential for injury or mortality of eggs and embryos is negligible. The footprint of the HORG has experienced annual disturbances since

the conception of the rock barriers in 1963 (see *Existing Conditions and Previous Consultations in the Action Area*) and lacks suitable habitat for spawning adults and their spawn.

Transport of Larvae and Young Juveniles (Spring: ~ March – June)

Any delta smelt larvae that hatch in the area surrounding the proposed HORG are likely to be entrained or eaten and thus will not contribute to the population. This conclusion is based on extensive hydrodynamic modeling that shows extremely low probability of water and by extension, planktonic animals like fish larvae, being transported away from the south Delta export pumps except in very wet years in the San Joaquin basin.

Rearing Juveniles (Summer/Fall: ~ July – December)

The southern Delta does not support delta smelt rearing during the summer. Delta smelt densities decline below 20-mm Survey detection limits by the end of June and typically fall below the much more sensitive detection limits of the south Delta fish facilities during June or July.

Population-level

Delta smelt have been found as far upstream on the San Joaquin River as the City of Mossdale, which is upstream of the HOR, but delta smelt that migrate into the south Delta are faced with high risk of entrainment and predation. As a result, most of the delta smelt population is distributed downstream of the proposed HORG. Available monitoring data suggest that adult delta smelt occur in very low numbers near the HORG. Over 2,300 beach seine samples in the San Joaquin River between Dos Reis (RM 51) and Weatherbee (RM 58) between 1994 and 2016 yielded four delta smelt (all in February–April) (Service 2016). Nearly 30,000 trawl samples at Mossdale from 1994 to 2016 resulted in the capture of 44 delta smelt, principally in March-June (Service 2016).

The low abundance of delta smelt and low quality of potential spawning habitat in the vicinity of the HORG indicates that impacts from construction will have undetectable population-level effects. Based on the low abundance of delta smelt in the San Joaquin River in the vicinity of HORG, potential adverse effects on migration and survival of migrating adults will likely be limited to a small proportion of the population.

Summary

The proposed HORG construction work window is expected to avoid affecting delta smelt because they are not expected to be present in this location at this time of year (August 1-October 31). Habitat within the footprint of the HORG has become heavily altered and disturbed with the annual installation of the temporary HOR rock barrier that is installed most years in the spring and fall (see *Existing Conditions and Previous Consultations in the Action Area*). By permanently installing an operable gate within that footprint there will be a loss of 2.9 acres of shallow water habitat that is proposed to be mitigated for as described in the *Description of the*

Proposed Action. That mitigation will provide a greater overall conservation value to the delta smelt than the habitat that is being lost due to construction of the HORG.

9.2.2.1.5 Clifton Court Forebay, Clifton Court Forebay Pumping Plant, and Connections to Banks and Jones Pumping Plants

Effects to Individuals and the Population

Individual-level

Construction activities at CCF that may affect delta smelt include expansion and dredging of SCCF, construction of divider wall and east/west embankments, dewatering and excavation of NCCF, construction of NCCF outlet canals and siphons, and construction of a SSCF intake structure and NCCF emergency spillway. Of those identified activities, effects to delta smelt and its critical habitat have previously been addressed for some components of the PA in prior consultation with the Service in the 2008 Service BiOp. Delta smelt can only occur within the CCF by operation of the SWP. Therefore, this BiOp addresses those additional affects to delta smelt and its critical habitat outside of the previously analyzed footprint in the 2008 Service BiOp. Construction within and near the CCF may alter (increase or decrease) the number of delta smelt salvaged at the existing CVP and SWP pumping facilities when compared to what has been described in the 2008 Service BiOp incidental take statement. However, there are limitations to the delta smelt effects analyses based on the information provided to the Service in the CWF BA and best available information; it is too speculative to determine how salvage estimates of the existing CVP and SWP pumping facilities will be affected by the implementation of the PA. Effects to individuals from exposure to in-water work activities at CCF exposure that have previously been accounted for in the 2008 Service BiOp incidental take statement are described below.

Contact with Heavy Equipment or Material

Delta smelt could be injured or killed by contact with equipment or materials during in-water construction activities in CCF and the adjacent Old River channel. In addition to the proposed in-water work window, DWR proposes to implement a number of AMMs to minimize the potential for impacts on delta smelt, including AMM1, *Worker Awareness Training*; AMM4, *Erosion and Sediment Control Plan*; AMM6, *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material*; AMM7, *Barge Operations Plan*; AMM9, *Underwater Sound Control and Abatement Plan*; and AMM8, *Fish Rescue and Salvage Plan* (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*).

Increased Turbidity and Suspended Sediment

In-water construction activities at CCF will result in elevated turbidity and suspended sediment levels in CCF and Old River. The principal sources of increased turbidity and suspended sediment are dredging and cofferdam construction (sheet pile installation and removal). Minor

increases in turbidity and suspended sediment in CCF and Old River are also expected during construction of the CCPP, outlet canals and siphons, SSCF intake structure, and North CCF (NCCF) emergency spillway. All other sediment-disturbing activities within cofferdams, upland areas, or forebays pose little or no risk to water quality.

The potential for elevated turbidity and suspended sediment to affect delta smelt will be minimized by restricting all in-water construction activities to July 1-October 31 (when delta smelt are least likely to be entrained by operations), limiting the duration of these activities to the extent practicable, and implementing the AMMs described in CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*.

Dredging could cause extensive, long-term effects on turbidity and suspended sediment within CCF. Potential secondary effects include potential increases in chemical and biological oxygen demand associated with the decomposition of vegetation and organic material in disturbed sediments. In addition to implementing the AMMs listed above, DWR proposes to limit the potential exposure of listed species to water quality impacts by restricting the timing, extent, and frequency of major sediment-disturbing events. For example, DWR proposes to limit the extent of dredging impacts in CCF by restricting daily operations to two dredges operating for 10-hour periods (daylight hours) within 200-acre cells enclosed by silt curtains (representing approximately 10% of total surface area of CCF). In addition, dredging will be monitored and regulated through the implementation of the *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan*, which includes preparation of a sampling and analysis plan, compliance with NPDES and SWRCB water quality requirements during dredging activities, and compliance with proposed in-water work windows.

Exposure to Contaminants and Disturbance of Contaminated Sediments

Contaminated sediments can adversely affect fish through direct exposure from mobilized sediment or indirect exposure through accumulation of contaminants in the food web. Consequently, dredging, excavation, and expansion of CCF pose a substantial short-term and long-term risk of exposure of delta smelt and other aquatic organisms to elevated concentrations of contaminants. Current estimates indicate the dredging will affect up to 1,932 acres of CCF while expansion of the SCCF will create an additional 590 acres of newly exposed sediment. The proximity of the south Delta to agricultural, industrial, and municipal sources indicates that a broad range of contaminants that are toxic to fish and other aquatic biota, including metals (e.g., copper, mercury), hydrocarbons, pesticides, and ammonia, could be present. Mud and silt in south Delta waterways have been shown to contain elevated concentrations of contaminants, including mercury, pesticides (chlorpyrifos, diazinon, DDT), and other toxic substances (California State Water Resources Control Board 2010). Impairments in Delta waterways also include heavy metals such as selenium, cadmium, and nickel (G. Fred Lee & Associates 2004). Thus, exposure and resuspension of sediments during in-water construction could lead to degradation of water quality and adverse effects on fish or their food resources in the action area.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and

disposal of contaminated sediments, as described under AMM6, *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material*, in CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*. These measures include the preparation and implementation of a preconstruction sampling and analysis plan to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (*e.g.*, silt curtains) to achieve compliance with existing Basin Plan objectives will be important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

Underwater Noise and Vibrations

During construction of the CCF water conveyance facilities, activities that are likely to generate underwater noise include in-water pile driving, riprap placement, dredging, and barge traffic. Pile driving conducted in or near open water poses the greatest risk to delta smelt because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Other activities such as riprap placement, dredging, and barge operations generally produce more continuous, lower energy sounds below the thresholds associated with direct injury but may cause harm and harassment to individuals resulting in avoidance behavior or temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

Pile driving conducted in or near open water can produce underwater noise of sufficient intensity to injure or kill fish within a certain radius of the source piles. Pile driving information for CCF is available for the embankments, divider wall, siphon at NCCF outlet, and siphon at Byron Highway (CWF BA 2016, Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*). Pile driving operations include the installation of an estimated 19,294 temporary sheet piles to construct the cofferdams for the embankments and divider wall, and 2,160 14-inch diameter concrete or steel pipe piles to construct the siphon at the NCCF outlet. Pile driving for the siphon under Byron Highway is not addressed in the following analysis because all pile driving will be conducted on land and more than 200 ft from water potentially containing listed fish species. A total of 4 construction seasons will likely be required to complete pile driving operations based on the estimated duration of pile installation (CWF BA 2016, Appendix 3.D, *Construction Schedule for the Proposed Action*).

DWR proposes to minimize the potential exposure of delta smelt to pile driving noise by conducting all in-water construction activities between July 1 and November 30 (when delta smelt are least likely to be entrained by operations). In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (CWF BA 2016, Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9, *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit